Vaccination.

By W. Harrison-Martindale, Ph.D. Marburg.

The terrible severity of variola, or smallpox, now threatening the largest centre of population in the world, is practically nnknown to the present generation, yet it has been estimated that 60,000,000 human beings died of smallpox in the eighteenth centnry. In Iceland, where the disease had previously not been known, during the years 1707 to 1709 18,000 of the population of 50,000 were swept away by its ravages. In Ware, in an epidemic in 1722, the few who escaped attack did so only with the firm conviction that they were to "have the smallpox." With this conviction, that sooner or later every hnman being must pass through the disease to either die or remain on earth hopelessly pitted and disfigured, there grew up a practice of inoculating the system with variolons matter, and nursing the patient carefully—as things were in those days—through the disease thus communicated. This idea of inocnlation is probably of very ancient origin, having been in vogue, it is said, in India in ancient times; and similarly a method of communicating the infection was employed in China by placing a small quantity of smallpox crust in the nostrils. The method, like present-day vaccination, was not condncted gratuitously—it was known as "bnying the smallpox." In more recent times it was practised in Turkey, whence, through the instrnmentality of Lady Mary Wortley Montagu, it was introduced into England. Whether this inoculation did more harm than good has always been a debated question — it was satisfactory to the individual bnt by no means so to the commnnity, and there is every reason for the belief that though the inocnlated disease was nsually of a mild character, infection was spread throughout the country and many persons took smallpox who otherwise would not have had it.

Tracing events further, we come to May 14, in the year 1796, on which Edward Jenner, a Gloucestershire practitioner, "vaccinated" a yonth of 8 years of age with "lymph" taken directly from a pustule of a dairy-maid who had become accidentally infected with a disease prevalent at the time amongst cattle, termed cow-pox. This accidental infection is termed "casual" to distingnish it from the intentional form which is the snbject of these notes. Though giving Jenner all honour, it is possible the idea was not absolutely new on earth. There exists, I nnderstand, in the British Mnsenm, a Sanskrit docnment, according to which a priest is said to have been called to a prince who was sick unto death with smallpox. He told the prince that had he been snmmoned earlier, he could have overcome the evil by inserting nnder the skin a thread steeped in the matter of a cow with pox. He wonld, the priest stated, have passed through a slight fever, to be restored to health and strength again. The prince died.

Jenner had long been making observations on the preventive power exercised by this cow-pox over smallpox. The fact that having been previously thns infected conferred immnnity to smallpox was, indeed, commonly known amongst the Gloucestershire farmers, and it was a conntry girl who taught Jenner this—to us now—simple lesson, some time prior to the date mentioned. Trne to his expectations, all went well with Jenner's first "vaccinated" patient, and the next point was to ascertain whether the "vaccination" really prevented smallpox. After waiting six weeks he was able to satisfy himself as to this by inoculating the yonth with variolons matter—withont any resnlt. Later, on the occasion of a further outbreak of natnral cow-pox, he was able to transfer vaccinal infection from one hnman subject to others, which, speaking briefly, clinched the matter. In 1798 Jenner pnblished his epoch-making "Inquiry," and in a little while he became famous throughout the civilised world. Continuing on these resnlts, attention was drawn to a similar disease in other animals—*e g.*, "grease" in horses and swine-pox. Jenner was doubtless slightly in error in thinking that "grease" was in reality an antecedent of the bovine form, and that it was communicated probably by hnman aid from the horse to the cow. Investigations proved eqnine and bovine forms of the disease to be of common origin, if not identical, and, in addition to the now cnstomary "calf-lymph," many strains of equine vaccine have been raised and used for vaccination.

With the appearances of the arm on vaccination all are well acqnainted; but it may here be stated that three or four distinct stages are claimed—firstly, there is a tranmatic reaction, which subsides; then the *papule* is prodnced by an increase of intercellular fluid, which is specific, and from which it is possible to vaccinate; vacnoles gradnally appear in the centre, by the extension of which the papnle becomes the *vesicle*; and, finally, the *pustule*, containing pnrulent matter, is produced. It may be mentioned that the aim of modern vaccinators is not so mnch to produce the old-time inflammation, but to procure a small typical "pock" in due conrse, thereby discomforting the patient as little as possible. Although authorities differ as to the conduct of some of the details, the following procedure is a well-recognised method of vaccinating. One should be vaccinated every fourteen years.

Rules for Vaccinating.

1. Sterilise a small lancet just before use by holding in the flame of a spirit-lamp.
2. Clean the arm by means of a little ether soap or absolute alcohol, or both (no antiseptic is necessary), and blow out the contents of a tube of lymph on to the surface, using a small rubber syringe ball, which fits on the tube. Avoid the older method of ejecting the lymph by the mouth, as this, besides being entirely foreign to modern principles of asepsis, may result in an unfortunate vaccination of the lips of the operator.
3. Scarifications are made in four or five sets, each set having an appearance similar to two "sharps" on a sheet of music, and being not larger in diameter than ¼ inch. They should also be placed an inch or so apart from each other, to prevent the possible confluence of the resulting vesicles.
4. The lymph is rubbed and pressed into the skin at these points, stretching the skin the while.
5. The arm is kept exposed for a little time. This may favour absorption. Wrap with a pad of antiseptic dressing.
6. Though the lymph will keep well for months in the sealed tube, it should be used at once when opened.
7. Make it a rule to again sterilise the lancet after each vaccination.

Variola and Vaccinia Compared.

At the commencement of vaccination by means of calf-vesicle pulp, there arose naturally a sceptical community who qnestioned the preventive power which mere "vaccination" with the product of an animal infected with cow-pox could possess over smallpox, as the two diseases were thought by many to be distinct, and in spite of nnmerous and indefatigable investigations there exist to this day a faction who maintain that this is so. These experiments, having for their aim the production of cow-pox in the cow or calf by inoculation of variolous matter from the human being, have been attempted in Great Britain with considerable success (by, *e g.*, Badcock, Simpson, Copeman, Klein), in Germany (by Voigt and Fischer), in Switzerland (by Haccius and Eternod), and in India (by King and Simpson). The order mentioned is not chronological. The first-named —a Brighton chemist—succeeded in variolating a cow, and supplied large quantities of lymph to the medical profession from his result. Copeman was snccessfnl in one instance out of fonr. Together with Klein, his resnlts differed from those of the other investigators mentioned, in the respect that they obtained no vesicles in the animals, at any rate, none in the first inoculation (but on one or two removes, however); whereas the other workers—Badcock, Haccins and Eternod, King, Simpson, &c.—claimed to have obtained, at or near the seat of inocnlation, a vesicle resembling the vaccine-vesicle. Hence the conclusion is that variola has been altered and modified, by passage through the calf, to vaccinia cansing the typical vaccine-vesicle, yet without prodncing a general eruption. Furthermore, as vaccinia so produced can be transferred again to the hnman being withont serious resnlts, this ground is even more tenable. The most reasonable assnmption, as Copeman states, is probably that variola and vaccinia have a common ancestor.

The Variolous Test.

Inocnlation with smallpox in the times of Jenner, as has already been pointed ont, was a general rontine method of protection, and we may regard as an indirect ontcome of it what is known as the "variolous test," consisting simply of inoculation with variolous material to test the

efficacy of vaccination. Nowadays inoculation of the human being under any pretext whatever is a penal offence, but here Nature assists the investigator by providing monkeys for his research. That monkeys are susceptible to variola (contrary to previous opinion) has been demonstrated by Copeman and others. Monkeys are available in many parts of the world, and this variolous test will doubtless be applied, as suggested in a recent editorial in the *British Medical Journal*, for the investigation of a "sport" form of variola of mild character, now prevalent in America.

Animal Vaccination.

By this is understood the communication of the virus of cow-pox to man. The "calf-lymph," obtained in the way to be described, may be said to consist of the plasma of blood, together with corpuscular elements, bacteria, and the virus from the vaccinal organism, the identity of which will be discussed under another heading. The original stock of the vesicle-pulp used must have been obtained from a case of true natural cow-pox. In 1879 a report was drawn up for the use of the Conference on Animal Vaccination, in which the advantages of animal lymph over human lymph were set forth. A full account will be found in the *British Medical Journal* of November 9, 1879. Briefly it amounts to this: Animal vaccination has the important advantage in that the subject is not open to all varieties of disease which might be communicated from the "source." It might be urged that the patient could become affected with some disease from which the calf might be suffering, but this is entirely *extra muros*, as, in the first instance, few of these diseases are communicable to man; and, in the second place, they are so easily recognised in the animal that a calf so infected could not possibly be admitted for lymph-manufacture. Lymph of long humanisation may have lost much of its power of protection, and the patient vaccinated with lymph of this kind may be liable to smallpox infection. The protection afforded with calf-lymph is more thorough and lasting.

By the courtesy of Dr. Renner, I was recently permitted to closely observe many of the details of lymph-manufacture, and some interesting information was secured. In the early days when he commenced the manufacture and distribution of calf-lymph, the doctor was accustomed to keep his premises open for vaccination direct from the calf, but since the introduction of the accustomed tubes this is no longer necessary. To commence the work of lymph-manufacture it is obviously necessary to first find one's cow with spontaneous cow-pox. In Dr. Renner's case it is on record (*B.M.J.*, i., 81, 663) that his strain of lymph originated from a case of natural cow-pox which occurred at Beaugency, a small village in France. Lymph from this animal was sent to a vaccination-establishment in Holland, and there the propagation was carried on from calf to calf through, at that time of writing (April, 1881) close on six hundred generations without a failure, and from one of these descendants Dr. Renner obtained the lymph with which he vaccinated his first calf. In the course of after-events it was obviously impossible to maintain that particular strain of lymph down to the present day. The doctor's practice now is to select and propagate the strain which has been found to be the most active.

The Bacteriology of Lymph.

On this subject an immensity of work has been conducted, and now and again some investigator comes forward with the statement that the specific organism has been discovered. The great difficulty in the matter is that the organism—as doubtless there is one—objects to grow upon any of the media usually employed for bacterial culture. One of the first workers was Chauveau (his results being afterwards confirmed by Burdon Sanderson), who proved that clear filtered lymph is no longer active, the activity being in the "particles" left upon the filtering-medium. Quist showed that the "specific contagium" could exist for a time in the presence of glycerin. Cohn, Klebs, Feiler, Guttman, and many others have also worked on the subject. Crookshank found a large number of bacteria, including micrococci, bacilli, torulæ, &c., none of which could be looked upon as the cause of vaccinia.

Klein has reported upon an extremely minute bacillus found both in calf-lymph and in variolous human lymph. It was, however, impossible to cultivate the organism. Copeman made observations similar to those of Klein, and detected the minute organism in the skin of a calf-vaccine vesicle. He succeeded in cultivating the organism by means of egg-cultures with remarkably satisfactory results. Saint-Yves Ménard confirmed Copeman's views to the effect that organisms which may be isolated by ordinary means are in no way specific. In conjunction with Blaxall, Copeman found the following organisms (arranged in order of prevalence): (1) *Staphylococcus cereus flav.* and *Staphylococcus cereus alb.*; (2) Yeasts of three varieties; (3) *Staphylococcus pyogenes alb.*; (4) *Staphylococcus pyogenes aur.*; and (5) *Staphylococcus pyogenes citr.*, together with *B. mesentericus*, *B. subtilis*, moulds, and sarcinæ which are merely chance contaminations.

Leaving these investigators, we may glance at those who, finding the bacteriological footpaths too downtrodden, have gone further afield to the crops of a higher form, and who would assign the vaccinal power, for example, to a protozoon. Of these amongst many others are Pfeiffer, Ruffer, and Guarnieri. The parasite found by the last-named is called by him *Cytoryctes vaccinæ*, and may be observed on histological examination in the tissue alongside the nuclei within twenty-four hours of vaccination. Bacteriologists, however, do not favour these views—Copeman, for example, thinks these parasites probably represent "the result of epithelial irritation caused by the scarification, together with that—of a non-specific nature, however—set up by the vaccine lymph employed."

The Preparation of Calf-lymph.

Well-fed female calves are selected, kept under careful supervision for a week to detect any sign of disease, examined by a veterinary surgeon, and if found apparently suitable are vaccinated as follows: The calf is placed on a tilting-table. A large portion of the lower abdomen is shaved and washed with phenol solution, then with sterile water, and finally dried with sterilised towels. By some a previous disinfection of the calf with formalin-vapour is conducted. Incisions, scarifications, or punctures are then made in the cleansed surface as deep as possible, but without drawing blood. Glycerinated lymph which has been found to be free from "extraneous" organisms—*i.e.*, those which are totally unnecessary (as described under the examination of lymph)—is then allowed to run into these incisions, or by some it is rubbed in all over the surface with a spatulum. After five days the vesiculation will be in full progress as depicted in the photograph kindly lent by Dr. Renner. The animal is again placed on the table, and the entire surface is well washed and dried with the strictest aseptic precautions. If the operation has been successful, the vesicles exhibit the typical central depression, and in the event of sets of punctures having been made close together originally, they run together to form one continuous swelling. Any scabs which may have formed are carefully taken off. The first portion of liquid lymph is allowed to escape, and the vesicle-pulp is carefully removed by means of a Volkman spoon into a weighed sterile bottle. In this process care is taken to prevent the admixture of blood. The calf is then killed and examined by the veterinary surgeon who forwards his report. This report is always awaited before issuing to the medical profession. The calf is none the worse for the process, except that it is killed.

Glycerination.

More than fifty years ago it was discovered that the addition of glycerin to "lymph" prevents decomposition and keeps it in a fluid condition for a considerable time. To those initiated with the simple theory of glycerination there is nothing more droll than inquiries for "fresh lymph—must be glycerinated." The reason is that glycerinated lymph is purposely kept for a varying period of from six weeks to six months before it is issued for vaccination. The vesicle-pulp having been collected in the sterile vessel as described, is weighed and mixed forthwith with one and a-half times its weight of glycerin; this is the proportion adopted by Dr Renner, but some establishments dilute considerably more. Dr. Renner informs me he has no occasion to dilute to a greater extent than that mentioned, the supply being equal to the demands of the most extensive epidemic. As an

stance of the amount which in times of stress he is able to pply, the doctor informed me that during the week ıding October 5 he sent out 21,512 tubes of fully-matured mph.

Copeman and others, by a series of far-reaching experiments, ıve proved the value of glycerination, all "extraneous" ganisms being gradually killed off, until at the end of a onth only a few spore-bearing organisms hold the field in mpany with the redoubtable De Wet of the battle—the ıestionable "vaccinal organism." Copeman, Klein, and hers have shown that even the villainous tubercle bacillus ıes under in this sweeping glycerin-war. If the collection the lymph be carefully conducted, the comparatively in- ›cuous spore-bearing organisms may be excluded. Indeed, is possible to produce an absolutely sterile lymph in this

The Illustration Shows the Vaccine-vesicles in a Calf on the Fifth Day.

ıy. During the process of glycerination agar plate-cul- ıres are conducted, by means of which the killing-off process ıy be observed.

Filling the Tubes.

The next operation is to reduce the vaccinal pulp and ycerin to a state of fine comminution. This is brought out by passing the mixture through a lymph-mixing or turating machine. There are two forms in use, both ıanating from the Continent. The first, invented by ›ring, of Berlin, is composed of four glass rollers arranged the familiar "mangle" system, through which, after ›rilisation, the lymph passes. The second, shown in use Dr. Renner's establishment, is known as Chalybäus's strument. After complete sterilisation of the parts, the mph-pulp is poured into the central funnel, through which core runs, which consists of a screw starting with a coarse ıread at the top and becoming gradually finer towards the ıse. This screw-core fits closely in a solid brass cylinder (also th screw), as the picture (p. 631) shows, all that is neces- ry is to work the screw on a table resembling a sewing- achine stand, by the foot, or by water or electro-motor power. The finely mixed lymph exudes from the base of the cylinder, and is collected in a sterile vessel. The product presents a turbid appearance, owing to the minute broken granular tissue and cells present, in which, as Dr. Renner claims, the vaccinal activity principally predominates.

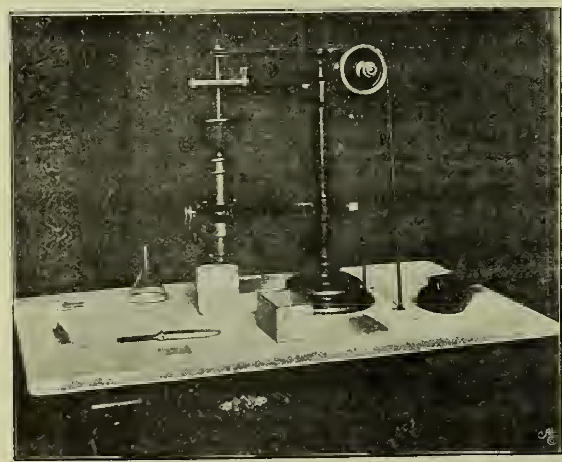
The filling of the tubes is the simplest part of lymph-production. At the time of filling, the glycerinated lymph is diluted with a very small quantity of sterile water, this addition being necessary as the pulp-and-glycerin mixture is otherwise too thick to run into the tubes. Capillarity and gravity bring about the desired result: a small quantity of the mixture is poured out on to a glass plate, and one end of the tube (open at both ends) is inserted into it, and then laid down on the edge, with the result that sufficient lymph enters. On sealing in a blowpipe-flame it is ready for distribution. The tubes before filling undergo a thorough sterilisation.

Bacteriological Examination of Glycerinated Calf-lymph.

The bacteriological examination of lymph is not fraught with any great difficulties. If, for example, it is desired to test a sample which has undergone glycerination for any length of time, all that is necessary is to transfer a small portion of it, with strict aseptic precautions, into a tube of melted sterile agar or gelatin and to prepare plate-cultures in the ordinary manner. Agar-cultures are looked upon as the more important, as most of the injurious parasitic organisms grow with greater strength at the temperature of the body (at which agar, and not gelatin, may be maintained). These plate-cultures may then be counted by means of a Pakes disc, and further cultures may be prepared from the colonies *secundum artem.* In addition to these, glucose-agar cultures may be made with the object of detecting the presence of any anaërobic organisms.

In 1895 Landman examined the lymphs from thirteen German institutes, and found organisms varying in number

between 50 and 2,500,000 per cubic centimetre. Recently—in April last year—the *Lancet* published a report of a Special Commission which had some time previously been appointed to thoroughly examine lymphs on the market in this country. In some initial experiments this Commission again established—broadly speaking—that when glycerin growths of a mixture of organisms are conducted until the number of organisms is "constant," nothing but non-pathogenic spore-bearing organisms remain. The opinion is expressed that the vaccinal organism is probably a spore-bearing one. A dozen or more samples of calf-lymph from various supply depôts were then reported upon, and it is



LYMPH TRITURATING MACHINE.

gratifying to be able to state that Dr. Renner's lymph heads the list as to bacterial purity. As already stated, by careful manipulation, absolute sterile lymph can be produced, but the Commission concluded that "so long as the non-spore bearing organisms are eliminated, and the spore-bearing and anaërobic organisms reduced to a minimum, it is not necessary to send out absolutely sterile lymph." This statement refers, of course, to such organisms as are capable of cultivation on ordinary media.

Some excellent pamphlets and leaflets regarding vaccination, for distribution more particularly amongst the poorer uneducated classes, may be obtained from the British Medical Association, 429 Strand, London.

Scientific Progress.

Gomenol.—This name has been assigned to the essential oil distilled from *Melaleuca viridiflora*, one of the myrtaceous plants of New Caledonia. It is a mobile liquid of sp. gr. 0·922, and rotatory power + 0° 42′. It appears to consist chiefly of terpene alcohols, and is intermediate in its general properties between camphor and menthol. Gomenol has been employed with success in cases of chronic broncbitis and pulmonary tuberculosis.

Chemistry of Oil of Theobroma.—J. Klimont (*Berichte*, 1901, 2,636) states that by fractional crystallisation of oil of theobroma from acetone, it can be separated into three main portions. That with the highest melting-point, melts at 64° C., and doss not absorb any iodine. Crystals melting at 70° C. were isolated from it, and found to be a mixture of the triglycerides of stearic and palmitic acids. The second portion, melting at 31° to 32° C., had the empirical composition $C_{55}H_{104}O_6$, and a saponification number 196·4. It was a mixture of the triglycerides of palmitic, oleic, and stearic acids. The third portion melted at 26° to 27° C., had a saponification number 210·5, and an iodine number 31·7. Its constitution was not determined, but it appears certain that the triglyceride of oleic acid does not occur in this fat.

Alkaloids of Corydalis Cava.—A complete summary of the results which have been obtained in the recent examinations of this drug is published by Gadamer in the *Pharmaceutische Zeitung* 1901, 775). The following bases were already well known: corydaline, corybulbine, corycavine, bulbocapnine, and corytuberine, and lastly, corydine an amorphous alkaloid described by Merck. A very exhaustive examination of the mixed bases by treating the the ammonia extract with ether has shown that the following may be separated. Ether extracts, a series of alkaloids which may be directly crystallised, including corydaline, corybulbine, corycavine, and bulbocapnine. There is then left an amorphous mixture, which appears to be Merck's corydine. This can be separated into several crystalline bases, and several which are really amorphous. The former include isocorybulbine, of the formula $C_{21}H_{25}NO_4$, melting at 179°–180° C.; corycavamine, $C_{21}H_{21}NO_5$, melting at 149° C.; corydine, either $C_{21}H_{25}NO_4$ or $C_{21}H_{23}NO_4$, melting at 129°–130° C. In addition, there is a base melting at 135° not further investigated. The amorphous bases include a base which yields a well crystallisable hydrochloride, and a mixture of bases which yield only amorphous salts, and which have not yet been investigated. The base corytuberine remains in the ammoniacal extract, and is not taken up by the ether. [Compare Dobbie on the same subject, *C. & D.*, December 15, 1900, page 948.]

Constitution of Citronellal.—Harries and Schauwecker, in the current issue of the *Berichte*, publish an exhaustive investigation into the constitution of the aldehyde citronellal. This body has been somewhat neglected on account of the prominence given to its ally, citral. The paper includes a good account of the aldehyde, commencing with its discovery by the American chemist Dodge. The original formula assigned to it by Tiemann and Schmidt was

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>C{:}CH.CH_2CH_2CH(CH_3)CH_2.CHO.$$

The correctness of this formula was first questioned by Barbie and Lèser, who suggested

$$\begin{matrix}CH_3\\CH_2\end{matrix}\!\!\geqslant C.CH_2.CH_2.CH_2.CH(CH_3)CH_2.CHO.$$

The present work, which has attacked the problem in an entirely fresh manner, supports the latter formula, and the concluding remarks of the paper are to the effect that the natural olefinic compound citral, linalol and methylheptenone, may possibly have analogous formulæ, which would then be as follow :—

$$\begin{matrix}CH_3\\CH_2\end{matrix}\!\!\geqslant C.CH_2.CH_2.CH_2.C(CH_3){:}CH.CHO = \text{Citral.}$$

$$\begin{matrix}CH_3\\CH_2\end{matrix}\!\!\geqslant C.CH_2.CH_2.CH_2.C(OH)(CH_3).CH{:}CH_2 = \text{Linalol.}$$

$$\begin{matrix}CH_3\\CH_2\end{matrix}\!\!\geqslant C.CH_2.CH_2.CH.CO.CH_3 = \text{Methylheptenone.}$$

Oriental Storax.—Tschirch and Van Itallie, who have recently published an account of their investigations on America storax, also give an account (*Apotheker Zeitung*, 1901, 505) c their work on the Oriental variety. They have examined ths frs acid from a number of samples, and find that it is pure cinnami acid, and have not in any case been able to find even traces (benzoic acid. Small quantities of an aldehyde were separated, a in the case of the American variety, and were found to be vanillii although the quantity was too small to allow of a full examina tion. The combined cinnamic acid was found to be present i the form of the ethyl and the phenylpropyl esters. The mai resin constituent was found to be the ester of cinnamic acid an an alcohol, which the authors term storesinol (that from America storax they have termed styresinol). When carefully purifie storesinol is free from ash, and forms white odourless powdei fragments, which are strongly adherent when rubbed for a sho time. It melts at 156° to 161° C. [A feature which does not se much for the individuality of this so-called compound.—Ei *C. & D.*] It is soluble in alcohol, methyl alcohol, amyl alcoho ether chloroform, acetone, carbon disulphide, benzene phen acetic acid, and caustic alkalies. It is insoluble in petroleu ether. A series of combustions—which, however, are of vei little use in determining the formula of a complex compound i the absence of other evidence—gave results which agree well wi the figures $C_{16}H_{26}O_2$. It form a compound with potassium t heating with a solution of caustic alkali, and is reduced to mixture of volatile hydrocarbons by distillation with zinc dus Well-defined ethers were prepared, and also a bromine compoun Styrol and styracin were also found in the balsam. The quanti tative results of the examination are as follows :—

	Per cent.
Insoluble in ether	2·4
Water	14·0
Styrol and vanillin	2·0
Free cinnamic acid	23·1
Aromatic esters	22·5
Resin compounds	36·0

The acid number of the storax was 81, the ester number 98, ar the saponification number 179. The saponification figure of tl esters and styrol was 209. The total cinnamic acid was 47·3 p cent., of which 23·1 per cent. was free, and the remainder cor bined.

NUMERATION TABLE.

I.	Units	1 Units 2 Tens 3 Hundreds
II.	Thousands . .	4 Units 5 Tens 6 Hundreds
III.	Millions . . .	7 Units 8 Tens 9 Hundreds
IV.	Billions	10 Units 11 Tens 12 Hundreds
V.	Trillions . . .	13 Units 14 Tens 15 Hundreds
VI.	Quadrillions . .	16 Units 17 Tens 18 Hundreds
	&c.	&c.

The periods succeeding those contained in the table are *quintillions*, *sextillions*, *septillions*, *octillions*, *nonillions*, and analogous names might be formed for still higher periods. Those given, however, are more than sufficient to express any number which it is ever necessary to designate in language. Such, indeed, is the facility with which large numbers are expressed, both by figures and language, that we have generally a very imperfect conception of their real magnitudes. For instance, we can pronounce readily the word *billion*, yet calculation informs us that there are not a billion of seconds in seven hundred and sixty-one years. Our eight hundred millions of national debt would, if represented by ten-pound notes of the Bank of England, each only the hundredth part of an inch in thickness, form a pile nearly thirteen miles high. To tell it in sovereigns, at the rate of a hundred every minute, for twelve hours a-day, (Sundays included,) would occupy one man for more than thirty years.

10. There cannot be now much difficulty in enunciating any number already expressed in figures. If we take a number, as 67543, we observe that it is composed of

6 tens of thousands, 7 thousands, 5 hundreds, 4 tens, and 3 units,
or 67 thousands 5 hundred and 43,

which is the common form of enunciation.

Again, 17060080, divided into periods, is 17,060,080, and may be read

1 ten million, 7 millions, 6 ten thousands, 8 tens, or shortly,
17 million 60 thousand and 80.

the other, than when they are formed by three figures each. And observing the limits of the numbers most frequently in use, it will be seen that the most convenient periods are those of three figures. It must, however, be noticed, that it is customary in England to reckon by double periods, or periods of six figures each, as in the following table:—

COMMON NUMERATION TABLE.

I.	Units . .	1 Units 2 Tens 3 Hundreds 4 Thousands 5 Tens of Thousands 6 Hundreds of Thousands
II.	Millions . .	7 Units 8 Tens 9 Hundreds 10 Thousands 11 Tens of Thousands 12 Hundreds of Thousands
III.	Billions .	13 Units 14 Tens 15 Hundreds 16 Thousands 17 Tens of Thousands 18 Hundreds of Thousands
IV.	Trillions . .	19 Units 20 Tens 21 Hundreds 22 Thousands 23 Tens of Thousands 24 Hundreds of Thousands
V.	Quadrillions .	25 Units 26 Tens 27 Hundreds 28 Thousands 29 Tens of Thousands 30 Hundreds of Thousands
VI.	Quintillions .	31 Units 32 Tens 33 Hundreds 34 Thousands 35 Tens of Thousands 36 Hundreds of Thousands
	&c.	&c.

This is the table usually given in our English works on arithmetic, but it is now beginning to be laid aside for the far more elegant and simple method shown in the table of the text, which is used in all parts of the continent. The methods, moreover, agree as far as hundreds of millions, and it is rarely necessary to name higher numbers.

The following are other examples in illustration :—

Bills. Mills. Thous. Units.		
708, 000, 906, 000	is read	Seven hundred and eight billions, nine hundred and six thousand.
78, 906, 000, 400		Seventy-eight billions, nine hundred and six millions, four hundred.
7, 800, 600, 040		Seven billions, eight hundred millions, six hundred thousand and forty.
789, 060, 004		Seven hundred and eighty-nine millions, sixty thousand and four.
78, 906, 000		Seventy-eight millions, nine hundred and six thousand.
7, 890, 600		Seven millions, eight hundred and ninety thousand, six hundred.
789, 060		Seven hundred and eighty-nine thousand and sixty.
78, 906		Seventy-eight thousand, nine hundred and six.
7, 890		Seven thousand, eight hundred and ninety.
789		Seven hundred and eighty-nine.

The following numbers present no greater difficulty, viz.,

106, 1803, 98769, 80567804, 207000080,
108365, 9007867, 8006783401.

11. The expression of numbers by means of figures presents in reality no greater difficulty; for, each period being enunciated and qualified, it only remains to write each of them separately, and give it the rank which its name indicates. In the first trials, however, it may be advisable to make as many points as the highest name requires, and to mark off these into periods; the significant figures may then be written in their places, under the dots, and the blanks filled with ciphers. Thus, supposing the number to be written down is *five hundred and six million eight thousand and nine*, we know that the place of the *hundreds of millions* is the last of the third period; there must consequently be *nine* figures, or three periods, in the number, and we proceed accordingly to make three periods of dots,

Millions.	Thousands.	Units.
. . .	. . .	. . .
5 6	8	9

and filling up the unoccupied places with ciphers, we get for the true expression of the number,

506,008,009.

By a little practice the dots will be found unnecessary, and, of course, need not be used.

The following are examples of the same kind :—

Name.	Written.
Three hundred and nine	309
Seven thousand and sixty	7,060
Twenty thousand five hundred	20,500
Two millions one thousand and eleven . . .	2,001,011
One hundred and two millions five hundred and seventy-four	102,000,574
Twenty billions one million forty thousand one hundred and forty-nine	20,001,040,149

There will now be little difficulty in writing the signs for

Five hundred and eighty-nine,
Three thousand and thirty-seven,
Sixty-four thousand and eleven,
One million two thousand and five,
Four hundred and forty-eight millions.

12. The method of expressing numbers by means of signs, is usually distinguished by the term *notation*, and the method of reading numbers already so expressed, is termed *numeration*. The distinction does not, however, appear to be very necessary, and accordingly we often find writers using one or other of the terms indifferently to designate both the one and the other.

13. The method of numeration which we have here described, is comformable to what is denominated the *decimal system*.* But besides this there are other systems in common use. For example, we measure wood, &c., by feet and inches, the foot being equal to 12 inches, and the inch to 12 parts; that is, each

* *Decimal* from the Latin word *decem*, ten; because the value of the figures *increase* in a tenfold proportion from right to left, and consequently *decrease* in the same proportion from left to right.

superior name contains 12 units of its next inferior name; this system is therefore called the *duodecimal system* (from the Latin word for *twelve*). Our mode of counting money is a mixture of systems. We divide it into pounds, shillings, and pence, of which 12 pence make a shilling, and 20 shillings a pound. We write a number of pounds, shillings, and pence, thus, £2 : 5 : 11, where £ shows that 2 is pounds, and as shillings is the next lower name, and pence the next in succession to shillings, the meanings of the 5 and the 11 are obvious. This variation in the value of the units renders the calculation of sums of money more complex than those with abstract numbers. The same is likewise true of all our systems of weights and measures, as we will hereafter find.

14. The systems of arithmetical notation employed by the ancients, were exceedingly inconvenient and imperfect. They served laboriously to register a number that was not very great, but they could not afford the slightest aid in performing arithmetical computation. In the simple calculations which it was absolutely necessary to make, recourse was had to some sort of mechanical contrivance, of which the *Abacus* of the old Romans, and *Swan-pan* of the Chinese, are examples. To form a notion of such an instrument, it is only necessary to suppose a board with a number of lines drawn upon it, as represented in the figure, and that each pebble or counter placed on the space A denotes 1; each on the space B denotes 10; each on the space C denotes 100; and so on; so that, taking the ciphers for counters, the number represented by their disposition in the figure, will be 123142. With such an instrument, (considerably inferior, however,) the Romans made all their heavy calculations,* and noted the results by the letters of their alphabet. This method of writing numbers we have still retained for some purposes, as for marking the chapters of books, the year of the Christian era, hours on dial-plates, and so forth. The letters employed are I, V, X, L, C, D, M; the I to denote 1; the V, 5; the X, 10; the L, 50; the C, 100; the D, 500; and the M, 1000. IƆ has the same meaning as D, and CIƆ as M. These letters, when thus employed, are called *numerals*, and the principles upon which they are combined, so as to stand for intermediate and for higher numbers, are these:—

F	0
E	00
D	000
C	0
B	0000
A	00

The repetition of a letter denotes the repetition of the number it represents; thus, III denotes three ones, and XXX denotes three tens, and so on.

When a letter expressing a less number is placed *after* a greater, the values of the numerals are to be taken together. Thus, XI means ten and one, or eleven; LX means 50 and 10, or 60.

When a numeral of a less value is placed *before* one of greater, its value is to be deducted. Thus, IV means 5 *less* 1, or 4; XL means 50 *less* 10, or 40.

When Ɔ is annexed to IƆ, it increases the value of that character ten times. Thus, IƆƆ is 5000, and IƆƆƆ is 50,000. In like manner, CIƆ is increased in value ten times by prefixing C and annexing Ɔ. Thus, CCIƆƆ is 10,000, and CCCIƆƆƆ is 100,000.

Lastly, a line drawn *over* a numeral increases its value a thousand times. Thus, $\overline{X}$ stands for 10,000.

The following table exhibits these principles more fully:—

Units.	Tens.	Hundreds.	Thousands.
I 1	X 10	C 100	M or CIƆ 1000
II 2	XX 20	CC 200	MM or $\overline{II}$ 2000
III 3	XXX 30	CCC 300	MMM or $\overline{III}$ 3000
IIII or IV...4	XL 40	CCCC or CD..........400	MMMM or $\overline{IV}$..........4000
V 5	L 50	D or IƆ 500	IƆƆ or $\overline{V}$..........5000
VI 6	LX 60	DC or IƆC 600	IƆƆM or $\overline{VI}$..........6000
VII 7	LXX 70	DCC or IƆCC..........700	IƆƆMM or $\overline{VII}$ 7000
VIII 8	LXXX...80	DCCC or IƆCCC...800	IƆƆMMM or $\overline{VIII}$...8000
IX 9	XC 90	CM 900	IƆƆMMMM or $\overline{IX}$...9000

* The word *calculation* is derived from *calculus*, a pebble, pebbles being originally used on the abacus. In process of luxury, *tali* or little dies made of ivory, were used instead of pebbles, and small silver coins instead of counters.

The following particular cases of combination may be observed:—

XVII for..........17	DCCXIX for..........719	$\overline{VII}$CC for 7,200
XXIV..........24	CDXC, or XD..........490	$\overline{XXX}$XC..........30,090
XXXIX..........39	MDCCCXLI..........1841	CCIƆƆXL..........10,040

17

ANATOMY AND PHYSIOLOGY.

CHAPTER I.

INTRODUCTION.

There is *no subject* in which the people are so deeply interested as to know the structure and functions of their own bodies. And yet there is *nothing* of which they are in general so deplorably ignorant. In the pulpit they sometimes hear the exclamation, "that they are fearfully and wonderfully made," but it constitutes the sum and substance of their anatomical knowledge. How astonishing that mankind should exhibit so little curiosity to know themselves! Why do this apathy and ignorance prevail? It is because anatomy and physiology do *not* form an elementary branch of juvenile education. Juvenile teachers do *not* understand them, and therefore *cannot* impart them.

In consonance with the ignorance and practice of the old pedagogues of our ancestors, children are still compelled to waste too much of the best portion of their early lives in the useless study of guttural sounds, obsolete words, dead languages, Greek and Latin poetry, ecclesiastical dogmas, and abstruse catechisms; and this is boastingly misnamed a useful education. What a misnomer of knowledge! It is like gravely presenting an apprentice-boy a few childish toys to play with, instead of giving him useful tools and teaching him his trade. It is like teaching astrology instead of astronomy—alchemy instead of chemistry—metaphysics instead of phrenology—magic instead of science—charlatanerie instead of surgery—and superstition instead of wisdom. It is making mankind move forever in one limited circle, and beyond it everything seems dark and mysterious. It is teaching them to quake like children at a thunder-storm, instead of disclosing the laws of electric phenomena—pointing the iron rod to the clouds, and directing the lightning to pass harmlessly into the earth. It is glorious for mankind that some philosophers have boldly overleapt the prescribed limits of their scholastic education, fearlessly examined the structure and laws of matter, and honestly explained them to the people. Galileo, Franklin, and Sir Isaac Newton, have burst the gates of superstition, opened to us the lucid windows of heaven, and we now behold the celestial phenomena with rational delight, and understand them.

Harvey discovered the circulation of the blood only by examining the human body, and studying its laws—not by bowing down with reverence to the dogmas of schools—and he banished from anatomical cloisters the hypothetic jargon of licensed empiricism, and in despite of medical anathemas and persecution, gloriously triumphed. Jenner unfolded the safety and utility of *vaccine inoculation*, and preserved the lives of millions of human beings, notwithstanding the outrages and selfishness of all the medical faculties of Europe combined to destroy it. Hundreds of anatomists, in almost every kingdom, have secretly dissected dead bodies, and disclosed their structure and functions to their pupils, although the arm of popular violence was often raised to annihilate them. In our own land, Sir Charles Bell has reaped immortal fame by his anatomical researches, and has explained the mechanism and laws of the animal machine to chirurgeons with as much accuracy and simplicity, as Watt has unfolded to engineers his extraordinary, yet simple, hydraulic engine.

In one short essay, very little knowledge can be conveyed of the structure and functions of the human body; it is only by commencing at the beginning of the subject, and proceeding with a regular series of articles in succeeding monthly journals to its termination, that we can learn to comprehend ourselves; and, after minute investigation, the skilful arrangement, symmetry, uses, and beauty of the animal machine will be rationally per-